

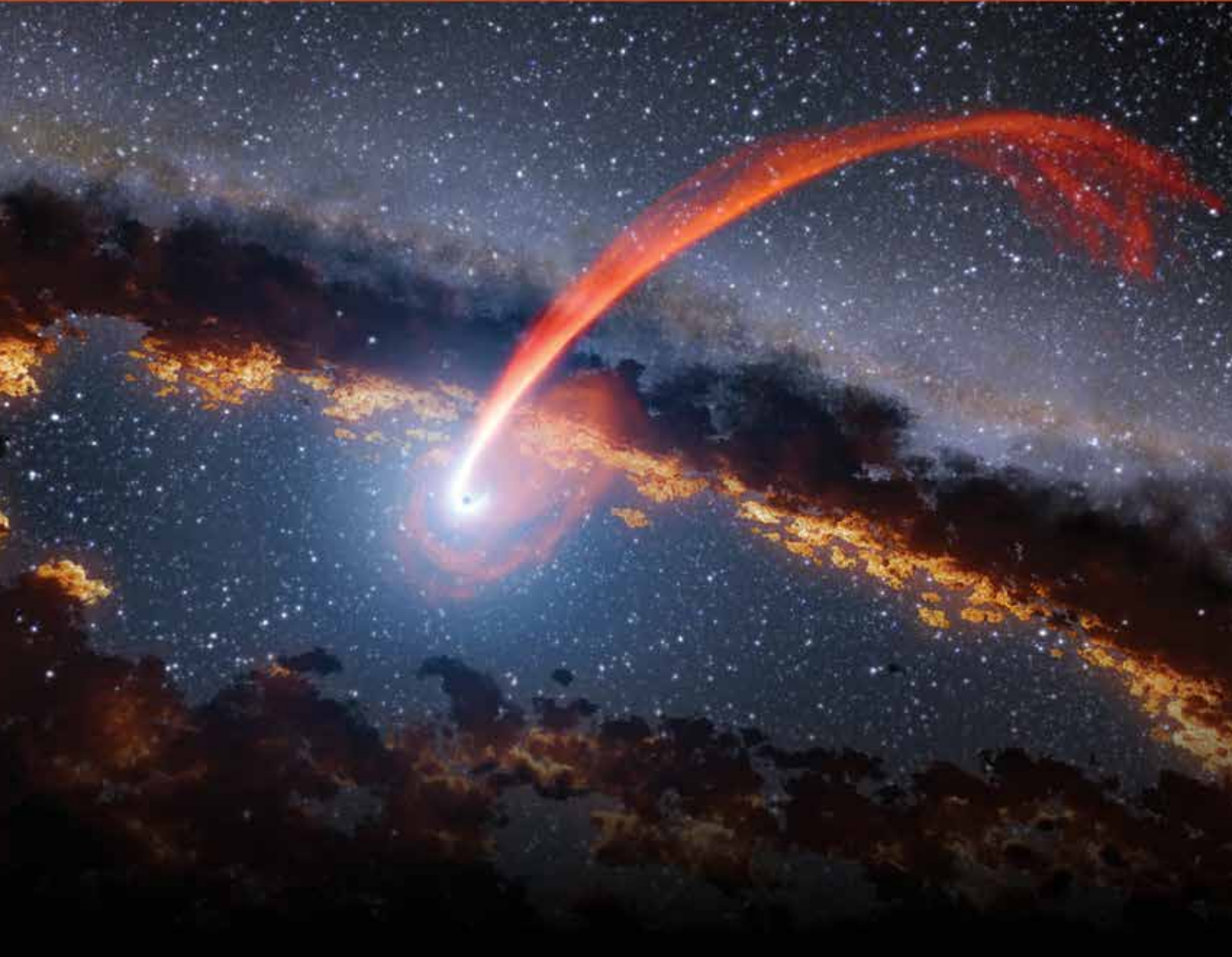


National Aeronautics and  
Space Administration



R O U N D U P

FALL 2016



Our journey to **Mars**

# The director of JSC

## Ellen Ochoa



PHOTO: NASA

### JOHNSON SPACE CENTER: LEADING THE WAY ON THE JOURNEY TO MARS

Johnson Space Center is key to all of NASA's highest priorities, and we should take pride in the work we're accomplishing in Houston. In this issue, you will read about our center's priority areas and learn about the tremendous progress we've made on the journey to Mars.

Our employees' efforts remain vital to our ability to advance human space exploration beyond low-Earth orbit, and I am committed to engaging our workforce so we can carry out our mission: **Lead human space exploration.**

I've made a variety of changes since I've become center director to ensure our senior leaders are empowered to create a culture of change. We must constantly think about how we can transform the way that we are doing business to make the best use of the resources we receive. I feel a sense of urgency at NASA to make sure that we are focusing on change. There's no guarantee that we will continue to be asked to lead five or 10 years from now—unless we continue to show that we are evolving.

That's the whole idea of JSC 2.016, which is about advancing human spaceflight by being lean, agile and adaptive to change. Change can be in terms of technology, processes or how we collaborate with our

partners. It means being open to new ideas. It means helping our organizations define acceptable risk. It's about saying, "Yes, if ..." when new thoughts come forward or possibilities for new collaborations come up, rather than saying, "We're too busy."

JSC 2.016 is also about being good stewards of the precious dollars that we've been given. We have a difficult mission to do. JSC 2.016 efforts are about how we can be more efficient and effective. How can we collaborate across organizational lines to get the most value? Let's work together. Let's break down barriers.

NASA will host an agencywide innovation day called the Agency Innovation Mission on Nov. 1 and 2. A variety of inter-center activities will take place to emphasize the importance of innovation and to solicit new ideas about the work that we conduct. I encourage all employees to take part and share your thoughts at one or more of the events here.

As always, I invite you to send your questions and suggestions to [JSC-Ask-The-Director@mail.nasa.gov](mailto:JSC-Ask-The-Director@mail.nasa.gov). We've posted answers to frequently asked questions on the JSC 2.016 internal website. If you're a part of the Twitterverse, follow me at [@Astro\\_Ellen](https://twitter.com/Astro_Ellen).

*Ellen Ochoa*

NASA/PHOTO



Patients from the University of Texas MD Anderson Cancer Center in Houston spoke to Expedition 49 Flight Engineer Kate Rubins, currently living and working on the International Space Station, on Sept. 16 during a 20-minute Earth-to-space call.

Rubins, who has a degree in cancer biology, answered questions from several patients turned artists. In the fall of 2015, MD Anderson Cancer Center partnered with NASA's Johnson Space Center to design a hand-painted spacesuit decorated by patients recovering at the hospital to raise awareness about the benefits of pairing art with medicine. Rubins, retired astronaut Nicole Stott and other NASA personnel have lent their artistic talents to this project and worked as mentors to the patients in the past year.

Three spacesuits, HOPE, COURAGE and UNITY, were created during the project. Spacesuit UNITY was created at cancer hospitals in Germany, Russia and Japan with collaboration from astronauts from NASA's international partners, ESA (European Space Agency), the Russian Federal Space Agency and the Japan Aerospace Exploration Agency.

Rubins wore the COURAGE suit during the conversation.

Follow the Space Suit Art Project on Twitter at:

<https://twitter.com/Spacesuitart>



# Journey to Mars

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**JOHNSON SPACE CENTER'S** new mission statement is clear: **lead human space exploration.** Our nearly 14,000-member workforce furthers this great undertaking every day, pushing the boundaries of the known to discover innovations in science and technology that will expand our endeavors in space. Explorers at heart, the JSC team is taking huge steps forward on the path to Mars. Whether managing the International Space Station and Commercial Crew Programs, or serving as the home for astronauts and mission control, everything we do positions us for a bright future.

Close to home, we are perfecting our skillsets and knowledge with **Earth Reliant** projects like the space station. Reaching for the **Proving Ground**, we are planning new spacecraft and crew systems for ambitious plans like the Asteroid Redirect Mission. Though landing a human on the surface of Mars may be many years away, JSC is on the right track to ensure America's continued preeminence in space and is even now readying for **Earth Independence**.

Why do we do what we do? No matter how far away it takes us,

exploration is for the benefit of all humanity. JSC improves life for everyone by sharing its scientific and technological breakthroughs and challenging the idea of limitations. Life on Earth has changed radically thanks to innovations originally developed for off-Earth use, but even greater impacts are to be expected as we set our sights for Mars.

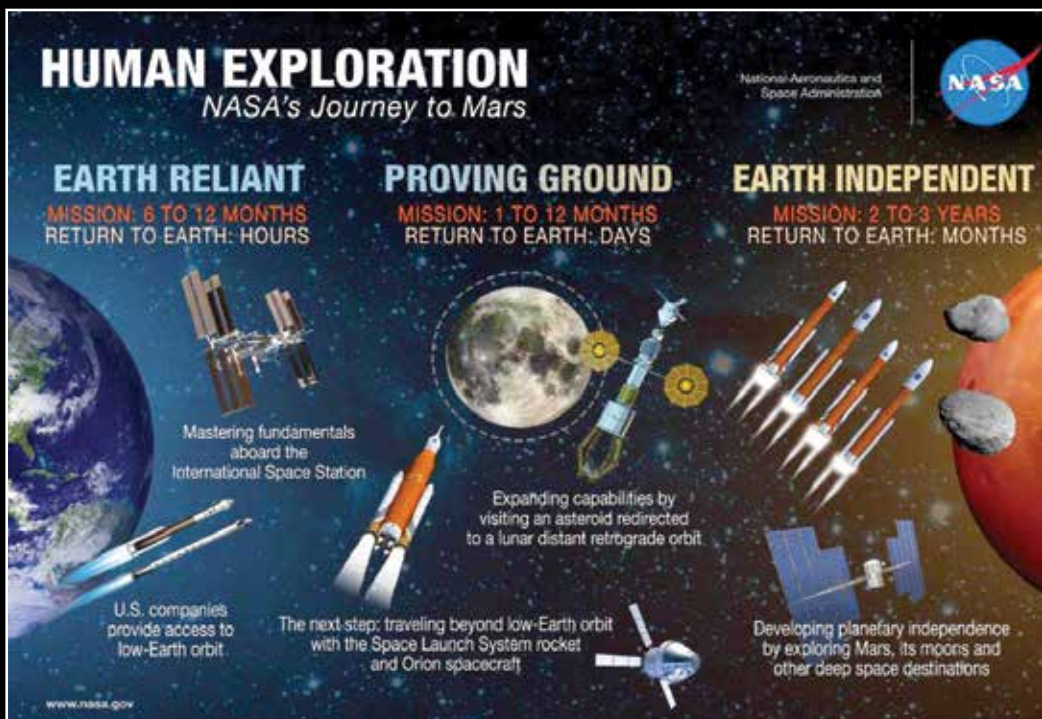
We are the leaders for human spaceflight architecture, the experts on science and planetary destinations and the primary center for Astromaterials Research and Exploration Science. Our mission plans, surface-system definitions and advances in human health and performance make daring goals possible.

JSC's work on spacecraft Environmental Control and Life Support

Have you visited the JSC Human Space Exploration website?

Find it at:

<http://www.nasa.gov/johnson/exploration>  
Accessible to the public, it shows how JSC is advancing the future of human spaceflight and is useful for those who want to know where we're headed—literally and figuratively—and how we're getting there. Visit it, bookmark it, share it.



This roadmap, representing NASA's Journey to Mars, shows the steps required for a purposeful pathway to the Red Planet. "This is really an agency view but, clearly, JSC is all over this picture," JSC Director Dr. Ellen Ochoa said at her All Hands on Sept. 6. "I believe we're the key player to making all of this happen."



## J O U R N E Y   T O   M A R S

Systems will ensure crew comfort during current missions and make future missions habitable and safe for humans. Likewise, our development of Entry, Descent and Landing systems, habitats, spacesuits and In-Situ Resource Utilization place needed resources at our fingertips. Advancement of robotic and autonomous systems implementation will see that astronauts on Mars have all the help they need.

### **Are we as smart as we think we are?**

Dr. John Charles, chief scientist of the Human Research Program (HRP), had worked with JSC External Relations to come up with a more engaging and understandable way to tell the general public why the one-year mission is important. It's a tough story to package into something easily understood; there are so many parts and subparts about what goes into the research that it's impossible to tell it all in a short 13-minute presentation.

After talking through some of the main points of the research, Charles was asked, "What would happen if we landed on Mars today?"

He paused, then started telling a story of what it would look like to have astronauts get out of a spacecraft that had just landed on the surface of the Red Planet after having launched on a rocket nine months prior. Their muscles would be weak. Their bones would be frail. They probably would not even be physically able to push the door open to get out—that is, if they could even see the door with all the vision problems they would have experienced upon landing.

This story became Charles' presentation. He went through the investigations of the one-year mission by painting this picture of



NASA/PHOTO

**NASA astronaut Jeff Williams takes a moment to capture a "space selfie" while on his final spacewalk outside the International Space Station. He and fellow NASA astronaut Kate Rubins were stowing an unused thermal radiator and installing external high-definition cameras to provide better quality views of external activities and approaching spacecraft.**

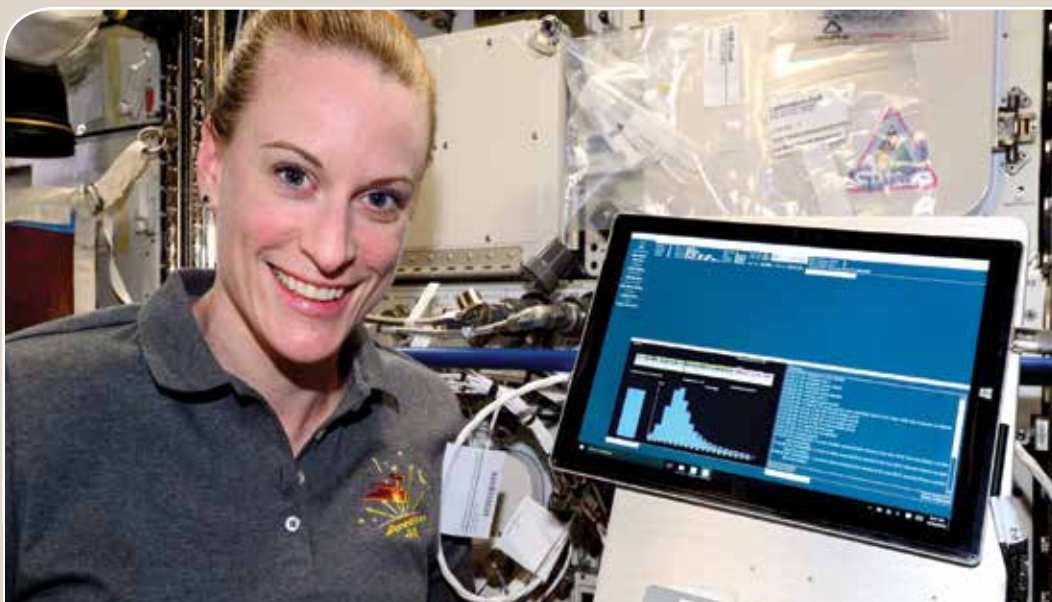
astronauts landing on Mars today. All the investigations that Charles and others in HRP are working on were presented as issues in this story of astronauts who had just landed on Mars. That presentation was streamed live to all NASA centers, and on YouTube has been viewed almost 100,000 times.

Charles ended his presentation by saying, "Are we as smart as we think we are?"

He was asking if NASA was ready for the journey to Mars based on all the research that had been done on the International Space Station over its lifetime so far.

There is a lot to learn before making this epic journey, and the space station is the perfect testbed to make sure NASA is truly ready. The one-year mission is just one collection of studies looking into what happens to the human body during extended forays into space, and its mission timeframe was just a little longer than the time it would take us to travel to Mars.

Astronauts contribute to



NASA/PHOTO

**Rubins sequenced DNA in space for the first time ever for the Biomolecule Sequencer investigation using the MinION sequencing device. This technology is also a 5x2015 project.**



A mock-up of Boeing's Starliner spacecraft is hoisted into position prior to drop testing at NASA's Langley Research Center in Virginia to evaluate the landing system when it touches down on solid ground.

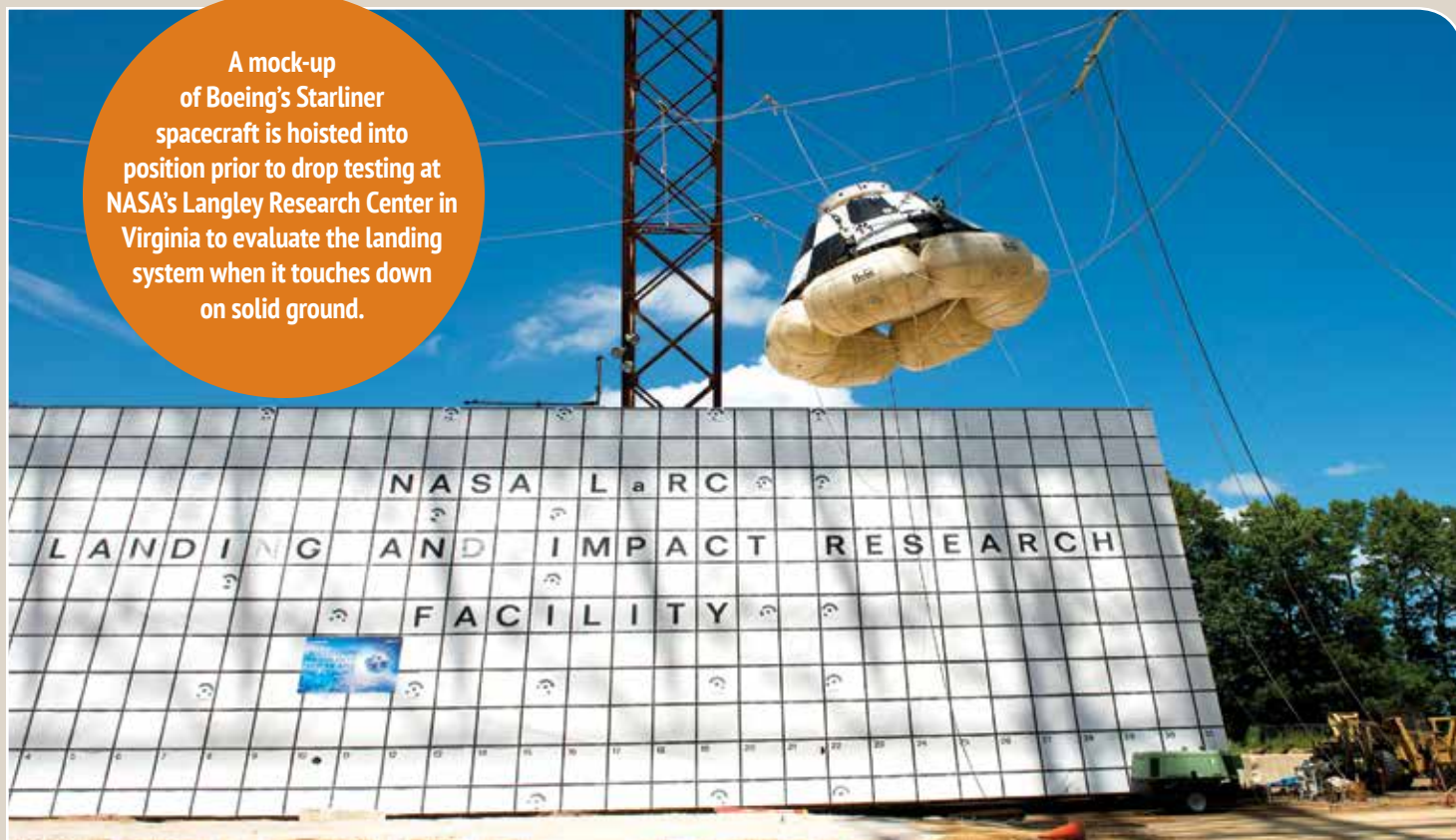


IMAGE CREDIT: NASA/LANGLEY RESEARCH CENTER

hundreds of investigations in biology, biotechnology, physical science and many more fields to help understand what innovations are necessary to make the journey to Mars successful. Scientists and engineers at JSC, as well as other NASA centers and partners around the globe, are constantly developing the building blocks for this voyage and improving upon the technologies required to make it happen.

The space station is the ultimate laboratory, especially when figuring out how humans can make that journey to Mars. But this is just the first step. There are many more to take.

### Traversing the cosmos—but from U.S. soil

The best laid plans for a trip to the Red Planet are just that—plans—without the regained capability to launch astronauts from U.S. soil. Once more, partnerships will make that possible.

As this year comes to a close, NASA and its Commercial Crew Program (CCP) partners will be within 15 months of launching astronauts to the International Space Station from the United States for the first time since the final space shuttle mission in 2011. The station is configured and ready with a new docking port adapter installed this summer.

Whether the first launch is a Boeing CST-100 Starliner atop a United Launch Alliance Atlas V, or a SpaceX Crew Dragon bolted to its Falcon 9 booster, JSC is an integral component to the success of these historic missions.

As with any crewed spaceflight, the Mission Control Center in Houston will serve as the focal point for Commercial Crew flight operations. Simulations have already begun in earnest.

Launch-to-landing mission operations of Boeing's Starliner will be conducted out of the new, state-of-the-art Flight Control Rooms, while direct oversight of rendezvous, proximity operations and joint missions will be handled by the International Space Station teams—also operating



IMAGE CREDIT: SpaceX

A SpaceX Crew Dragon test article lands at Delamar Dry Lake, Nevada, to complete a test of the parachute system.



out of a freshly modified and modernized room.

With hands-on input from astronauts and engineers across the agency, Boeing is building the CST-100 Starliner spacecraft, which will launch from Space Launch Complex 41 at Cape Canaveral Air Force Station in Florida.

SpaceX is building its Crew Dragon to launch on the company's Falcon 9 rocket from the former space shuttle Launch Complex 39A at NASA's Kennedy Space Center in Florida.

The complex avionics and software, flight computers, life support, communications and structural systems are being tested weekly as flight tests approach.

Behind the scenes, engineers within the CCP from JSC, Kennedy, Marshall Space Flight Center in Huntsville and other NASA centers continue the labor-intensive process of ensuring these spacecraft, launch vehicles and ground support network will be ready to support safe flights.

JSC has hosted water-based crew recovery demonstrations with military experts at the Neutral Buoyancy Laboratory. The docking systems for the Crew Dragon and CST-100 Starliner were tested here at JSC in the Six Degrees of Freedom Dynamic Test Simulator at the Space Vehicle Mockup Facility. JSC experts in micrometeoroid debris have worked with engineers from both partners to ensure the proper shielding is in place on the spacecraft to mitigate this top program risk.

Langley Research Center in Virginia has been the site for contingency water-landing simulations for Boeing's Starliner, which in reality will return to a soft landing on deployed airbags. Those tests are under way as well.

Later this year, Boeing will test Starliner parachute systems through a series of progressively more flight-like drop tests, including some high-altitude boilerplate releases.

SpaceX has begun its own landing tests with Crew Dragon. Parachutes and the riser connections are dropped from aircraft to evaluate deployment behavior. The tests will continue throughout this year and next, growing more complex and verifying the safety and reliability of the system.

Boeing's reaction control system thrusters and the launch abort engines also are being prepped for qualification tests before the

systems are installed for flight.

Meanwhile, a high-fidelity, 12-foot-long, 600-plus-pound Starliner/Atlas V wind tunnel model equipped with hundreds of sensors is providing engineers with volumes of dynamic and static pressure data to model vehicle aerodynamic loads and temperatures during ascent.

Boeing's CCP now occupies a former shuttle hangar at Kennedy, where the Starliner assembly, processing and checkout takes place before integration with its Atlas V rocket. SpaceX's Hawthorne, California plant hosts the manufacture and checkout of all components of its Falcon 9, cargo Dragon and all the complex systems of the Crew Dragon.

Next year is the final year for the assembly, checkout and flight



NASA/PHOTO

The Orion crew module structure was moved to the cleanroom at Kennedy for propulsion tubing welding, signaling a shift from structure assembly to installing critical systems.

test of these crew transports on the road to establishing a new highway to and from the space station.

## Orion team presses forward to first crewed mission

When a crew first sets foot on Mars, the milestone will be built, in part, upon the foundation laid by the thousands of people working on Orion, including a tremendous amount of effort and time expended this summer.

The Orion team has been busy assembling the spacecraft for its next mission, Exploration Mission-1 (EM-1) in 2018, and developing additional elements for its first flight with crew in 2021.

Orion's crew module for EM-1 was moved into the cleanroom at Kennedy in August, where it is being outfitted for the 2018 mission that will send the uncrewed spacecraft about 40,000 miles beyond the moon—a critical step on NASA's journey to Mars. In the



cleanroom, engineers began welding propulsion tubes, marking an important transition as the team moves from assembling Orion's structure to installing critical systems.

Meanwhile, a host of testing at NASA centers continued to ensure Orion's missions are as flawless as possible. Engineers at Glenn's Plum Brook Station in Sandusky, Ohio, continued testing a representative service module to confirm it can withstand the sound and shaking it will experience during launch.

At Langley Research Center, engineers completed a series of 10 water drop tests to assess how the capsule and its crew will fare during a variety of ocean splashdown scenarios. The successful test series helped validate computer models for extreme landing conditions, such as in cases of a parachute failure or an abort scenario after launch.

The parachute team kicked off its series in the skies above the Arizona desert to qualify the parachute system for missions with astronauts. And, here at home, a battery of human-factors testing provided data on Orion's hatch, hand controllers and radiation-protection procedures. Engineers vibration tested an Orbital Maneuvering System engine before its shipment to White Sands Test Facility in New Mexico, where it will be fired in the spring to certify the engine for use in the service module.

The Orion crew module at Johnson has been an important resource for a slate of human-factors testing, including summer evaluations of the docking hatch.



NASA/PHOTO



In spring and summer, engineers at Langley performed 10 tests of an Orion test article in the Hydro Impact Basin.

NASA/PHOTO



## Choose your own adventure

The sky is not the limit. NASA's journey to Mars is proving that with the proper ingredients, technological innovation and a dash of daring, humans can't be contained within the bounds of Earth's orbit. We want what the robots have already explored.

The question is: Where next?

Thankfully, we don't have to have the answers right now, right away. The flexibility of the agency's path to the red-hued planet allows for divergence to an asteroid first with the Asteroid Redirect Mission, or even the lunar landscape, if we choose to go back.

Create the technology and the capabilities first, and we can go. Anywhere.

**Onboard?**



Expedition 47 Flight Engineer Tim Peake of ESA (European Space Agency) took this striking photograph of the moon from his vantage point aboard the International Space Station on March 28. Peake wrote to his social media followers, "I was looking for #Antarctica—hard to spot from our orbit. Settled for a moonset instead."

This artist's concept shows the Origins Spectral Interpretation Resource Identification Security - Regolith Explorer (OSIRIS-REx) spacecraft contacting the asteroid Bennu with the Touch-And-Go Sample Arm Mechanism, or TAGSAM.



This view from the Mast Camera (Mastcam) on NASA's Curiosity Mars rover shows sloping buttes and layered outcrops within the "Murray Buttes" region on lower Mount Sharp on the Red Planet.





# One billion base pairs sequenced



**NASA astronaut Kate Rubins checks a sample for air bubbles prior to loading it in the Biomolecule Sequencer.**

**WHEN NASA ASTRONAUT KATE RUBINS'** expedition began, zero base pairs of DNA had been sequenced in space. Within just a few weeks, she and the Biomolecule Sequencer team had sequenced their one billionth base of DNA aboard the orbiting laboratory.

"I [have a] genomics background, [so] I get really excited about that kind of stuff," Rubins said in a downlink shortly after reaching the one billion base pairs sequenced goal.

This investigation will allow the implementation of the sequencer into operational microbial monitoring, a vast array of medical operations, a research facility on the International Space Station and integration into astrobiology-based exploration missions.

"The space station and Earth are end members of the gravity continuum, so if the device works on Earth and in microgravity, then

it should work in any environment in between, like an asteroid or Mars," said Principal Investigator Aaron Burton, Ph.D.

Learn more about the Biomolecule Sequencer and its sequencing of DNA in space: <http://go.usa.gov/xKeVb>

**The Biomolecule Sequencer is one of five 5x2015 projects with the potential for meteoric shifts in how we lead human space exploration. Read more about these game changers: <http://go.usa.gov/xKeVj>**

# 'White Mars,' then Red Planet

BY MONICA EDWARDS AND CHARLES LLOYD

**A TRIP TO THE RED PLANET** begins long in advance of liftoff. NASA's Journey to Mars includes preparing astronauts to cope with several months of isolation, confinement and in an extreme environment (identified with the acronym ICE). One of the best ways to study this on Earth is by observing others who also spend several months on *actual* ice in Antarctica.

NASA and the National Science Foundation (NSF), which manages the U.S. Antarctic Program, have a new collaborative agreement to study the effects of living in the polar environment.

In an initial research collaboration, a study developed and led by Dr. Candice Alfano, a clinical psychologist and associate professor at the University of Houston (UH), will analyze people who work in Antarctica for long periods of time.

It's relatively simple to place subjects in isolation or confinement for the purpose of studying mood and behavior, but the extreme environment element is harder to find.

Sometimes called "White Mars," Antarctica is perfect because "you can't walk off the ice. That goes for whether you're having a health, behavioral health or a personal issue, you're not going anywhere," said Lisa Spence, project manager for NASA Flight Analogs in the Human Research Program. "That is very similar to spaceflight. It changes your mindset about how you are going to respond when you know you can't leave."

Just how extreme is the extreme environment of Antarctica at the South Pole? Not only is 98 percent of the continent covered in ice, but it also has extreme winds and an average temperature range of minus 49 to 26 degrees Fahrenheit, making it the coldest place on Earth. At the South Pole, the sun disappears for months at a time. Known as "the Polar Night," the sun goes behind the horizon in late April and is not seen again until mid-September.

NASA astronaut Christina Hammock Koch has spent many seasons at various Antarctic and arctic stations helping scientists conduct research remotely, including a year at the South Pole.

"[This] means going months without seeing the sun, with the same crew, and without shipments of mail or fresh food," Koch said. "The isolation, absence of family and friends and lack of new sensory inputs are all conditions that you must find a strategy to thrive within."

While certainly a difficult situation, Koch found ways to cope. She exercised, found hobbies, socialized with others in the station and

saved care packages to open at later times.

"The most helpful strategy I developed was to avoid thinking about all the things I was missing out on and instead focused on the unique things in the moment that I would never get to experience again," Koch said.

These factors combine to create an atmosphere suitable for the NASA, NSF and UH study. Scheduled to begin in February, the study will include approximately 110 U.S. Antarctic program volunteers located at the McMurdo and South Pole stations.

By studying volunteers from both stations, researchers hope

to more precisely understand the greatest sources of stress. Volunteers will complete periodic computer-based questionnaires, provide saliva samples and wear a monitor that records sleep and wake cycles. Researchers will use these collective tools to look for signs of stress and changes in psychological health of the volunteers during their time in Antarctica.

The plan is to refine and finalize a checklist to be used to "provide an efficient means of monitoring signs and symptoms that a behavioral condition may be developing," said Lauren Leveton, Ph.D., of NASA's

Behavioral Performance team. "Therefore, allowing early detection and early intervention."

This checklist will be useful to NASA for future space travel, but Alfano points out that it will have other applications as well, such as among deployed military personnel.

Simultaneously with Alfano's study, the NASA and NSF partnership will deploy NASA clinical staff to Antarctica, which will give NASA flight surgeons a unique chance to treat individuals in the extreme environment.

NASA flight surgeons are on call around the clock for remote consultations with astronauts on International Space Station missions. Allowing these doctors to work in the Antarctic environment will give them additional training to call upon when consulting with the astronauts during future long-duration, deep space missions—like to Mars.

As NASA prepares for future human missions to Mars, keeping the astronauts safe on the journey is a top priority. The southernmost continent on Earth will provide researchers with the perfect analog for studying the behavioral health effects of an extreme environment.

*This article has been condensed. Read the full version at:*  
<http://go.usa.gov/xKVjT>



NASA astronaut Christina Koch takes a frozen selfie at the South Pole.





# All about **analog**s

## From seafloor to spaceflight

NASA/KARL SHREEVES



Pictured at the end of Mission Day 1 are the NEEMO 21 aquanauts, clockwise from top: Matthias Maurer (ESA), Marc O Griofa (Teloregen/VEGA/AirDocs), NASA astronaut Megan McArthur, NASA astronaut Reid Wiseman, Dawn Kernagis (Institute for Human and Machine Cognition) and Noel Du Toit (Naval Postgraduate School). Inside the Aquarius habitat are Florida International University Habitat Technicians Hank Stark (left) and Sean Moore (right).

The NASA Extreme Environment Mission Operations (NEEMO) 21 mission began on July 21 as an international crew of aquanauts splashed down to the undersea Aquarius Reef Base, located 62 feet below the surface of the Atlantic Ocean in the Florida Keys National Marine Sanctuary. The NEEMO 21 crew performed research both inside and outside the habitat during its 16-day virtual space mission. During simulated spacewalks carried out underwater, they evaluated tools and mission operation techniques that could be used in future spaceflights. Inside the habitat, crew objectives included testing a DNA sequencer, a medical telemetry device and HoloLens operational performance for human spaceflight cargo transfer.

## Visiting asteroids ... from Building 220

The Human Exploration Research Analog (HERA) Mission 11 crew successfully “splashed down” on Aug. 10 at NASA’s Johnson Space Center (JSC) in Houston. This 30-day, on-Earth simulation paves the way for future human research in the HERA habitat. HERA is one of several research analogs used by the Human Research Program to prepare NASA astronauts for deep space missions, such as missions to an asteroid or Mars.

Experiments included testing hardware prototypes, creating equipment with a 3-D printer, testing out a new concept for space food, flying a simulated exploration vehicle and virtually conducting a spacewalk on an asteroid.

While the HERA crew conducted their research inside the analog, the HERA analog team and researchers monitored them from the outside. They collected crew data on effects of extended isolation and confinement, team dynamics and conflict resolution.

On Sept. 19, the HERA Mission 12 crew began their 30-day simulated mission to an asteroid from their isolated home inside the confines of Building 220. This is the fourth and final mission for Campaign 3 and 2016.

The  
HERA Mission  
11 crew, from left:  
Emmanuel Urquieta,  
Daniel Surber, Kyle  
Foster and Tess  
Caswell.



NASA/JAMES BLAIR

Next year, Campaign 4 will extend the HERA missions to 45 days. A minimum of 16 subjects will be needed for those demanding assignments.



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Catherine Ragin Williams Editor  
Logan Goodson Graphic Design  
Lynnette Madison NASA Publication Manager

OR CURRENT RESIDENT

## Asteroids wanted (but no need to apply)

### Bennu, we're coming for you.

The United Launch Alliance Atlas V rocket with NASA's Origins, Spectral Interpretation, Resource Identification, Security-Regolith Explorer (OSIRIS-REx) spacecraft onboard is seen illuminated in the distance in this 30-second exposure on Sept. 7 at Cape Canaveral Air Force Station in Florida.

OSIRIS-REx powered to space on Sept. 8 at 6:05 p.m. CDT. It will be the first U.S. mission to sample an asteroid, retrieve at least two ounces of surface material and return it to Earth for study—specifically, right here at Johnson Space Center. The asteroid, Bennu, may hold clues to the origin of the solar system and the source of water and organic molecules found on Earth.

This robotic mission is just one precursor necessary in the pathway to the Red Planet.

Read more about Johnson's involvement with the samples here on page 8:  
<http://go.usa.gov/xK879>

IMAGE CREDIT: NASA/JOEL KOWSKY